COMMENTARY

Nourishing archaeology and science

Patrick Degryse[a,1] **and Andrew J. Shortland**[b]

[a]*Earth and Environmental Sciences, Centre for Archaeological Sciences, Katholieke Universiteit Leuven, BE-3001 Leuven, Belgium; and* [b]*Center for Archaeological and Forensic Analysis, Cranfield Forensic Institute, Cranfield University, Shrivenham SN6 8LA, United Kingdom*

Archaeology is an interdisciplinary science *par excellence*. In its quest to reconstruct human behavior in the natural and cultural environment of the past, archaeology uses knowledge and techniques from many different academic disciplines. Indeed, there are very few sciences that have no relevance to archaeology. The concept of "holistic archaeology" was specifically defined as an inclusive approach to archaeology, comprising all aspects of human societies, from ecology and economy, to social organization and politics, to art and ideology (1). In many excavation projects, however, the term has been particularly used to refer to the integration in archaeology of the work and results of exact or beta scientists, and less so to the work of anthropologists or humanistic scholars (2). The integration of the exact sciences into archaeological research has been led by those studying prehistoric sites throughout the world. Perhaps one of the key reasons for this is the very limitation of the evidence supplied by scattered, nonliterate, prehistoric groups and societies. Until recently, the efforts of prehistorians to include scientific analysis left scholars working on the great ancient civilizations far behind. The very wealth of evidence available here, especially that derived from abundant ancient textual sources, has militated against the application of scientific analysis on the same scale as that used in prehistory. However, that application is rapidly changing, especially with the understanding that the texts do not tell the entire story. More and more analysis is being conducted by established teams of researchers using advanced techniques. In PNAS, Clark et al. (3) present the chemical composition of organic balms used to prepare meat mummies, offerings of food especially prepared for the dead. This work complements previous work on animal and human mummies from ancient Egypt (4, 5), and uses advanced organic chemistry to answer some of the higher-level archaeological research questions mentioned above.

The production and preservation of food is fundamental to every society. Clark et al. (3) discuss the preservation of meat products, specifically that of birds and large mammals. Meat production could be broadly divided into two main categories: (*i*) the general production for routine consumption by either the population as a whole, or some elite subgroup of the population; and (*ii*) the production and preservation of meat products for ritual use. This second group could include meat for temple offerings and the victual mummies, designed to provide food for the dead [figure 1 in Clark et al. (3)]. As Clark et al. (3) state, the preservation of victual mummies sits at an interesting intersection between routine production and preservation of meat (which it resembles because it is a food product being preserved), and the much better known, studied, and much more widespread preservation of human and animal mummies (which have the ritual aspect, but not the food link).

In Egypt, the problems of producing and preserving meats are exacerbated by two key factors: urban living and climate. From the beginning of the fourth millennium B.C.E., we see the formation of a single state in Egypt and the growth of urban living. By the time of the objects analyzed, the second half of the first millennium B.C.E., urban areas were large and relatively abundant. Therefore, food had to be prepared at a distance and brought into the population centers, necessitating some time delay. The climate in Egypt was very similar then to what it is now. The heat would mean that meat would have to be eaten very quickly before it became bad, which would happen in only a matter of hours. There is, therefore, an absolute necessity to preserve food—especially meat products—and fast, to prevent them from spoiling. Very little is known about how this preservation was done day to day for large ancient

Fig. 1. Egyptian tomb model showing a scene of food preparation, including the butchery of a cow (*Lower, Right*), from Sedment, Egypt, ninth Dynasty (2160–2025 B.C.E.). Now in the Ashmolean Museum, museum no. AN.1921.1416. Copyright of the Ashmolean Museum, University of Oxford.

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[1]To whom correspondence should be addressed. E-mail: Patrick.Degryse@ees.kuleuven.be.

cities. The Egyptians did not write about such things in detail, and surviving meat from habitation sites is at best very rare. What do survive are iconographic representations in tombs of animal slaughter and, potentially, the preservation of the meat (Fig. 1). However, these scenes are often difficult to interpret and represent idealized views, not necessarily what was being carried out in actuality. To these interpretations can be added ethnographic observations from Egypt and elsewhere in the world. There is, therefore, very little information about the preservation of meat products in general in ancient Egypt, which makes the study of meat that was presented as gifts in tombs, as in Clark et al. (3), even more significant. These findings are the best view we have of what was a major industry, but for which direct evidence is lacking.

The other area where Clark et al. (3) have significant impact is that second intersection discussed above, the relationship to human and animal mummies. Human mummies are of course some of the most iconic remains to survive from ancient Egypt. These mummies have been studied in detail since the beginning of the 19th century A.C.E. The method of wrapping human remains, carried out by the people of Egypt throughout the millennia, is well known. Closely linked are animal mummies, which are extremely abundant, with millions of mummies of mammals, birds, and reptiles being produced as votive offerings for temples and tombs (4). Clark et al. (3) analyze the organic preservatives, such as bitumen, beeswax, and resins used in the mummification process, a relatively new approach in the study of mummies. The technique has been used on human and animal mummies from a variety of periods (4, 5), partly contemporary with the material studied by Clark et al. (3). Work on human mummies showed that, as could be expected, a wide variety of resins and balms were used, including balsamic resin, beeswax, bitumen, conifer resin, *Pistacia* resin, and plant oil, often mixed together (5). It was thought that animal mummies would not receive such lengthy and detailed treatment, especially given the high numbers that were produced. However, studies have shown that animal mummies received very similar treatments to human mummies, with once again a whole range of resins, gums, oils, and fats being used (4, 5). Clark et al. (3) present results on four victual mummies dating from the Egyptian New Kingdom or slightly after it, perhaps the height of Egyptian power and influence. These mummies are all from Thebes, the great ceremonial capital of Egypt near modern Luxor, from the West Bank (6), the "City of the Dead," specifically the Valley of the Kings (Yuya and Tjuiu, many other variations of the transliteration of these names are used), and tombs of high-ranking individuals, such as Isetemkheb.

The results show that three of the four victual mummies were apparently not treated with any organic balms or resins (3). This finding fits in with what is inferred about Egyptian meat production in general. The main preservation techniques for meat were probably various sorts of drying and salting (7). Previous work on victual mummies has suggested that these were the most common way the meats were preserved (7, 8), and previous work by scanning electron microscope showed salt crystals that were interpreted as evidence of meat salting (7). The salt used in mummification and preservation is termed *natrun* and is an evaporitic deposit of alkaline lakes. These deposits are a mixture of different minerals in varying proportions, mostly natron, trona, burkeite, and halite, all containing sodium (9). The source of the *natrun* used in this period is thought to be situated in the Wadi el Natrun in Northern Egypt, 100 km northwest of Cairo. This theory is mainly based on the writing of Pliny the Elder (10), although he also mentions other sources, which are interpreted as al-Barnuj in Egypt and current lake Pikrolimni in Greece (11). Other possible sources are at-Tarabiya in the Eastern Delta and al-Kab in Upper Egypt (12). However, Egypt, and most likely the Wadi el Natrun and al-Barnuj, is considered the main supplier of salt to the premedieval world. No unambiguous evidence exists for the use of either a single or multiple sources of salt during these times, although efforts are being made to develop a method for provenancing *natrun* salts (13).

By far the most interesting result from this analysis of the victual mummies comes from the tomb of Yuya and Tjuiu, which lies in the Valley of the Kings (14, 15). Yuya and Tjuiu were very significant members of the Egyptian elite, each with a string of titles, but perhaps most significantly they were the father and mother of Queen Tiye. Queen Tiye was the Great Royal Wife of Amenhotep III—that is to say, his principal queen—and as such she was perhaps second in power only to the King himself. The monarchs received a lavish funeral, and the tomb was discovered largely intact by J. E. Quibbel in 1905. It was the most important tomb to be found until the discovery of the Tomb of Tutankhamen (incidentally, Yuya and Tjuiu's great-grandson) by Harold Carter in 1922. That Yuya and Tjuiu belonged to the highest level in Egyptian society is beyond doubt, and so it is interesting that the victual mummy from their tomb is different from the others. The work of Clark et al. (3) shows that the tomb is preserved with a mixture of fat/oil and *Pistacia* resin, probably applied to the bandages. *Pistacia* was used in incense and in human mummies, and was a frequent part of the rituals of temple and tomb (16). Of the four species of *Pistacia*, only one is found in Egypt, and there is no evidence that this was exploited. It is likely, therefore, that this resin represents an import from the shores of the Mediterranean Sea or Levant. *Pistacia* resin has been detected in imported Canaanite amphorae found at the ancient city of Amarna, and in bowls from the same site, where it was burned as incense (16). Once again, there is a link to Yuya and Tjuiu, as the creator of Amarna was probably their grandson, King Amenhotep IV, later known as Akenhaten.

The fact that the most complex preparation for a victual mummy belongs to a very high-status tomb shows the owners' access to costly and rare resources. High status does not always equate to complex preparations, though, as relatively simply preserved meats are also found in high-status or royal tombs. Strips of meat interpreted as dried or salted biltong have been found in the tombs of Amenhotep II and Tuthmosis III in the Valley of the Kings (7). However, analyses by the techniques used in Clark et al. (3), are an excellent way to create a clearer picture of this important and fascinating aspect of ancient Egyptian ritual, life, and death.

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